Shaping ESO2020+ Together: Feedback from the Community Poll

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A thorough evaluation and prioritisation of the ESO science programme into the 2020+ timeframe took place under the auspices of a working group, comprising astronomers drawn from ESO's advisory structure and from within ESO. This group reported to ESO's Scientific Technical Committee, and to ESO Council, concluding the exercise with the publication of a report, "Science Priorities at ESO". A community poll and a dedicated workshop, held in January 2015, formed part of the information gathering process. The community poll was designed to probe the demographics of the user community, its scientific interests, use of observing facilities and plans for use of future telescopes and instruments, its views on types of observing programmes and on the provision of data processing and archiving. A total of 1775 full responses to the poll were received and an analysis of the results is presented here. Foremost is the importance of regular observing programmes on all ESO observing facilities, in addition to Large Programmes and Public Surveys. There was also a strong community requirement for ESO to process and archive data obtained at ESO facilities. Other aspects, especially those related to future facilities, are more challenging to interpret because of biases related to the distribution of science expertise and favoured wavelength regime amongst the targeted audience. The results of the poll formed a fundamental component of the report and provide useful data to guide the evolution of ESO's science programme.

In mid-2014, ESO embarked on a challenging exercise — evaluating and prioritising ESO's programme for the 2020–2030 timeframe on scientific grounds. A working group was formed, which included representatives of ESO's Scientific and Technical Committee (STC), Users Committee (UC) and Visiting Committee (VC), as well as the Very Large Telescope (VLT), VLT Interferometer (VLTI), Atacama Large Millimeter/submillimeter Array (ALMA) and European Extremely Large Telescope (E-ELT) Programme Scientists, plus a few representatives of the ESO Faculty with knowledge of ESO Operations. The composition of the working group is reflected in the author list of this article.

During its regular meetings (from May 2014 to April 2015), the working group discussed a variety of topics based on their main domains of expertise and devised a plan on how to proceed with the overall scientific prioritisation of ESO's programme. It recognised the importance of involving the community at large, as well as exploiting in-house expertise. Community involvement was in the form of a users' questionnaire and of a dedicated workshop. All these components were then taken into account in the final report, "Science Priorities at ESO", which was presented to the STC and to ESO Council. This report is now publicly available[1].

This article concerns the user poll, which was launched at the end of 2014 with the aim of discerning the scientific priorities of the ESO user community. The poll was designed to elicit clear guidelines from the community and to provide context for the ESO Workshop, ESO in the 2020s (held in January 2015, at ESO Headquarters), where preliminary results from the poll were first presented. Of the 9350 users who were invited to participate in the poll, 20 % completed the survey in its entirety. Here, we present the complete survey and highlight its main outcomes.

The poll: Basic facts

The poll was launched on 19 December 2014 with an initial deadline of 9 January 2015 in order to be able to report some preliminary results at the ESO2020+ workshop (19–23 January 2015). The poll remained open longer and was officially closed on 18 February 2015.

Professional astronomers (students, postdocs and tenured astronomers) registered in the ESO User Portal and in the ALMA Science Portal were invited to participate and share their scientific views. The poll was anonymous and contained four sections:

I. Tell us about yourself and your scientific interests (7 questions)
II. Present and future observing facilities (5 questions)
III. Time scheduling and observing modes (2 questions)
IV. Data management and services (5 questions)

Table 1. Questions from Section I of the ESO2020+ Users' Poll.

Section I – Tell us about yourself and your scientific interests		
1.1	What best describes your current position?	See Figure 1a
1.2	My home institution is located in	List of countries provided
1.3	My home institution is best described as	See Figure 1b
1.4	My primary focus is	See Figure 1c
1.5	I use data from these wavelength regimes	See Figure 1d
1.6	Your science: What are your main areas of scientific research? (check all that apply)	See Figure 2
1.7	Overall science vision: what are the top three research areas that in your opinion should dominate the astrophysical scene in 2020–2030?	See Figure 2

Section I was meant to collect basic demographic and professional aspects of the targeted audience: current position, country of present affiliation, type of home institution, main research interests (scientific area and wavelength domain), science vision for the 2020–2030 period. Section II followed up on the research interests and paired them to facilities, inside and outside ESO. Sections III and IV focused mostly on ESO science policy aspects and their implementation in terms of observing, data processing and data archive capabilities. The results presented here follow the structure of the poll. The following sections are devoted to sections I, II, III and IV of the user poll. Each section reports the lists of questions that were asked under that specific part of the poll (see Tables 1 to 4) and comments on the results. Graphical representations of as many responses as possible are included. The final section of this article adds some concluding remarks on the poll and indicates possible ways forward.

Out of the 9350 astronomers invited, a total of 1775 complete responses were received, representing close to a 20% response rate. In addition we received almost 400 incomplete responses, analysis of which is not included here.

We are aware of the weaknesses that polls often suffer in terms of biases and caveats, but we believe that the final numbers provide a relatively solid basis for our analysis of the results. Whenever applicable, we will spell out possible biases and caveats affecting the interpretation of the data.

Section I — Tell us about yourself and your scientific interests

The poll did very well in sampling the targeted audience, both in terms of geographical and professional distribution of the respondents. We received, on average, of the order of 20–25% response rates from all ESO Member States.

Figure 1 provides an overview on all the demographic aspects of the poll. Of the 1775 complete responses, slightly more than half come from tenured professionals, a third from young astronomers at

Figure 1. Overview of the main characteristics of the pool of poll respondents, in terms of career stage, home institution, main areas of research and wavelength domains.

Figure 1a.

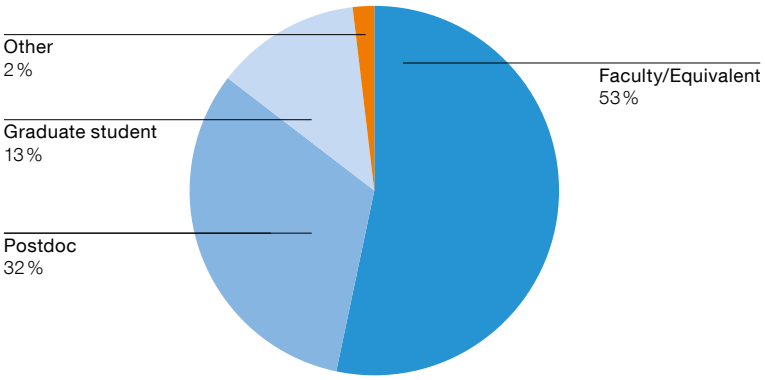


Figure 1b.

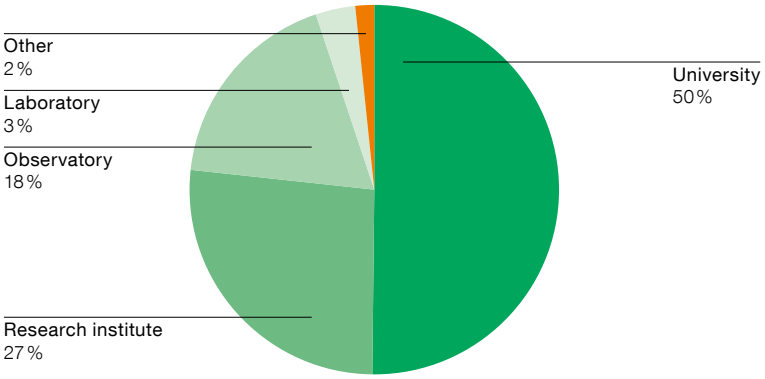


Figure 1c.

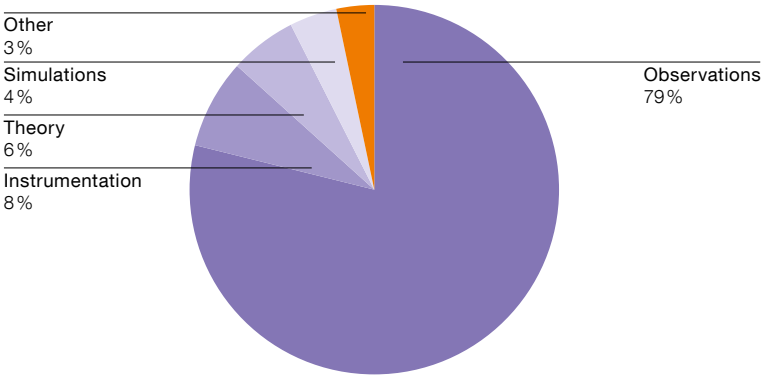
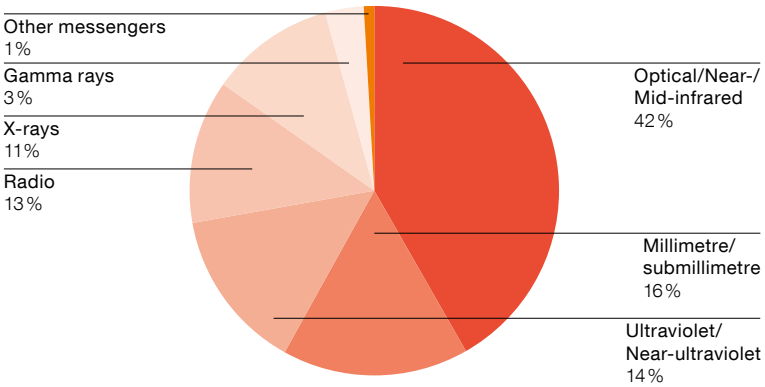


Figure 1d.



postdoctoral level and the remainder from students. Not surprisingly, the majority of the respondents work in observation-related research fields (79%). Half of the respondents work in an academic environment and most of them use optical/near-infrared/mid-infrared data. Part of this may be implicit in how the targeted audience of the poll was selected, with the ALMA Science Portal registered users contributing only a small fraction of the total (10% or 20%, respectively, depending whether one considers only the unique ALMA Science Portal registered users or also those who are registered on both portals). Moreover, it is important to note here that of the four pie-charts shown in Figure 1, the first three required a unique answer, whereas for the fourth — relating to wavelength domains — users were allowed to select several domains that apply to their research work.

Section I also aimed to collect the main scientific drivers of the community, now and in the future. The users were presented with two similar lists of research topics and asked to select first those that best describe their current research interests and then their science vision in the 2020–2030 timeframe (i.e., not so much about what they will be doing scientifically, rather what they think would be the research topics dominating in 2020–2030).

Figure 2 shows a direct comparison between the view of individual researchers on their research areas today and their science vision for the 2020–2030 decade, in terms of absolute numbers of preferences. While the topics structure/evolution of galaxies, stars and planetary systems dominate the pool today, planetary systems, cosmology/fundamental physics, search for life and structure/evolution of galaxies are foreseen to dominate the 2020+ astrophysical scene.

There exist some noticeable differences between the current areas of research and those fields expected to dominate the astrophysical landscape. Among the top four fields that will dominate the future (Figure 2), three are expected to increase significantly in popularity, the most affected one being the search for life. Two other areas of research are also expected to double their significance, but overall they represent a smaller fraction of respondents (extreme states of matter, pre-biotic chemistry).

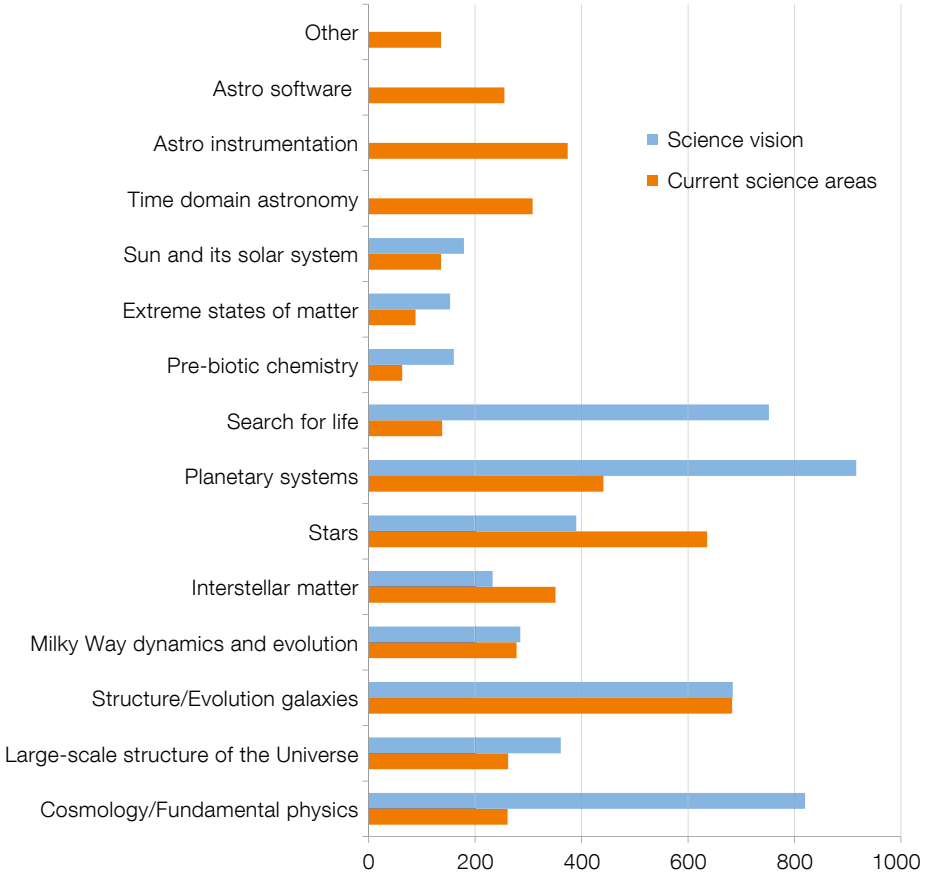


Figure 2. A direct comparison, in absolute numbers of preferences, between current individual research areas (light orange) and those identified by the respondents as dominating the astrophysical scene during the next decade (light blue). The four light orange bars at the top of the graph without a corresponding light blue bar correspond to the research areas that were omitted from the list of science vision topics.

The only research fields affected by a decrease in the number of preferences for the 2020–2030 decade are the more classical fields: stars and interstellar matter. If taken at face value, the outcome on the stellar field may be especially puzzling, considering that one of the main science cases for the E-ELT is concerned with resolving individual stars in external galaxies (for kinematic and chemical tagging purposes). Moreover, as will become apparent from the next section, this result is also at odds with the future capabilities and facilities identified by the community as most important. We note, however, that the two questions about current research interests and research areas dominating the future astrophysical scene were intentionally implemented with a slightly different logic. Question 1.6 (see Table 1), about current personal research interests, allowed the user to specify as many choices as necessary (in order to collect all their current research interests). Question 1.7, about the science vision, was instead restricted to a maximum of three choices (in order to collect only the most important areas, hopefully minimising the dispersion in the replies).

Section II — Present and future observing facilities

Section II followed up on the research interests emerging from Section I and paired them to the facilities that enable the users to achieve their science goals, inside and outside ESO's landscape.

Table 2. Questions from Section II of the ESO2020+ Users' Poll.

Section II – Present and future observing facilities		
2.1	Which capabilities will be most important for your research in the 2020+ timeframe?	See Figure 3
2.1.1	Please select the wavelength ranges and priorities for [your selection(s) of Q2.1]	See Figure 4
2.2	Are there observing capabilities missing at ESO for your research?	See text
2.3	Do you consider the support for visitor instruments an important capability for your research?	See text
2.4	Which facilities do your future research objectives require?	See Figure 5
2.5	Which other planned facilities are essential for your future research?	See Figure 6

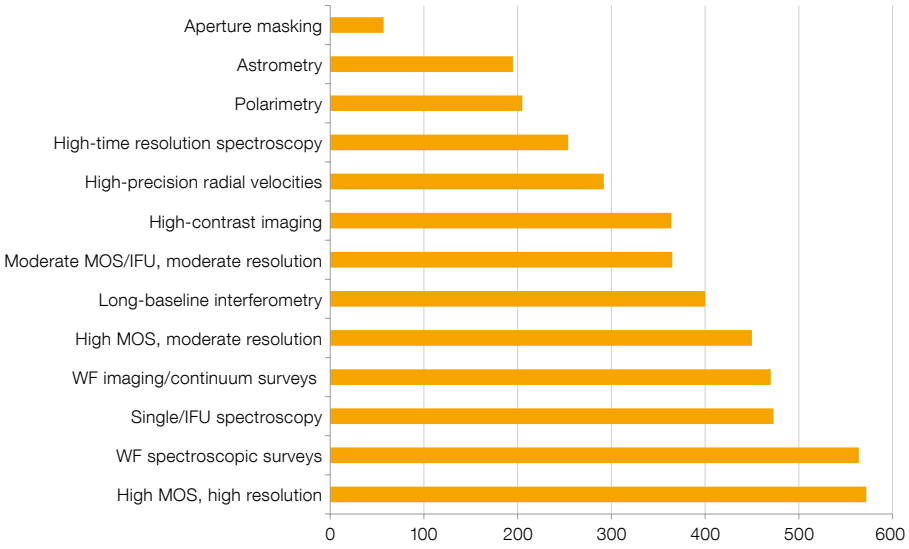


Figure 3. Users were asked to select the most important capabilities for their own research in the 2020–2030 timeframe. Responses are shown in absolute number of preferences, expressed for each option listed. A total of 4661 preferences were received.

The first question was about the most important capabilities for their research in the 2020+ timeframe. The respondents were allowed to make at most three choices and the distribution of all preferences is shown in Figure 3.

At face value, there seems to be a clear dominance of high-multiplex, high/moderate resolution spectroscopy, single/IFU (integral field unit) spectroscopy and wide-field (WF) imaging/continuum and spectroscopic surveys, which pairs well with the light orange bars displayed in Figure 2. However, interpreted carefully, Figure 3 is slightly more complex: first, by splitting the spectroscopic modes more finely than the other capabilities, we may be inadvertently boosting all spectroscopic entries; secondly, the analysis is based on a varying number of choices made by the different respondents (some may have chosen to specify all three choices they could make, others less); thirdly, the results may reflect the implicit bias in the targeted audience, because the number of users drawn from the ALMA Science Portal is at most one fifth of the total number of users who were invited to participate (depending whether one considers users with a unique account on the ALMA Science Portal — around 900 — and users who have an account on both portals — another 990). However, improving on the normalisation of the responses is not straightforward, because of the logic behind the questions. As noted earlier, this bias may reflect the distribution of wavelength domains among the respondents (see Figure 1), which in turn may be interwoven in the responses received in this section.

This first question was followed by a list of questions asking the user to specify, for each of the selected capabilities, the priority (Essential/Important/Somewhat Important) of different wavelength domains (0.3–0.4 μm, 0.4–1 μm, 1–2.4 μm, 2.4–20 μm, submillimetre [sub-mm], radio). We decided to combine all Essential/Important preferences given to each capability in the six wavelength domains (Figure 4) and normalise them to the total number of responses of the capability in the leading question. For example, the high multi-object (MOS), high-resolution capability received a total of 571 preferences (bottom bar in Figure 3); of those, 304 correspond to Essential/Important selections in the 0.3–0.4 μm interval, thus making up more than 50 % of the total.

With the exception of long-baseline interferometry, all the other observing capabilities received the largest number of preferences in the wavelength ranges 0.4–1 μm and 1–2.4 μm, followed by the 0.3–0.4 μm and the 2.4–20 μm intervals. The strong interest in the 0.3–0.4 μm region across all capabilities is noteworthy here, indicating a need for blue coverage that emerged also at the ESO2020+ conference.

For completeness, users were also prompted about the importance for their research that ESO continues to provide support for visitor instruments. The responses split almost equally between "Yes" and "No", with the latter leading just by a few percentage points (52 %).

After questions about capabilities, the users were asked about the facilities which were required by their scientific objectives. The net dominance of optical/infrared (IR) facilities (of any size, from 4 metre/8–10 metre, including a dedicated 10-metre spectroscopic telescope for the E-ELT) is notable. The detailed outcome is shown in Figure 5 and is based on a total number of 4575 choices (the answer was again limited to a maximum of three choices). As already commented for Figure 3, the replies may be affected by an implicit bias and reflect the wavelength range distribution of the user pool (see Figure 1).

Section II also touched upon the lack of specific facilities at ESO and the importance of other planned facilities (where users were asked to select all those that will be essential for their research

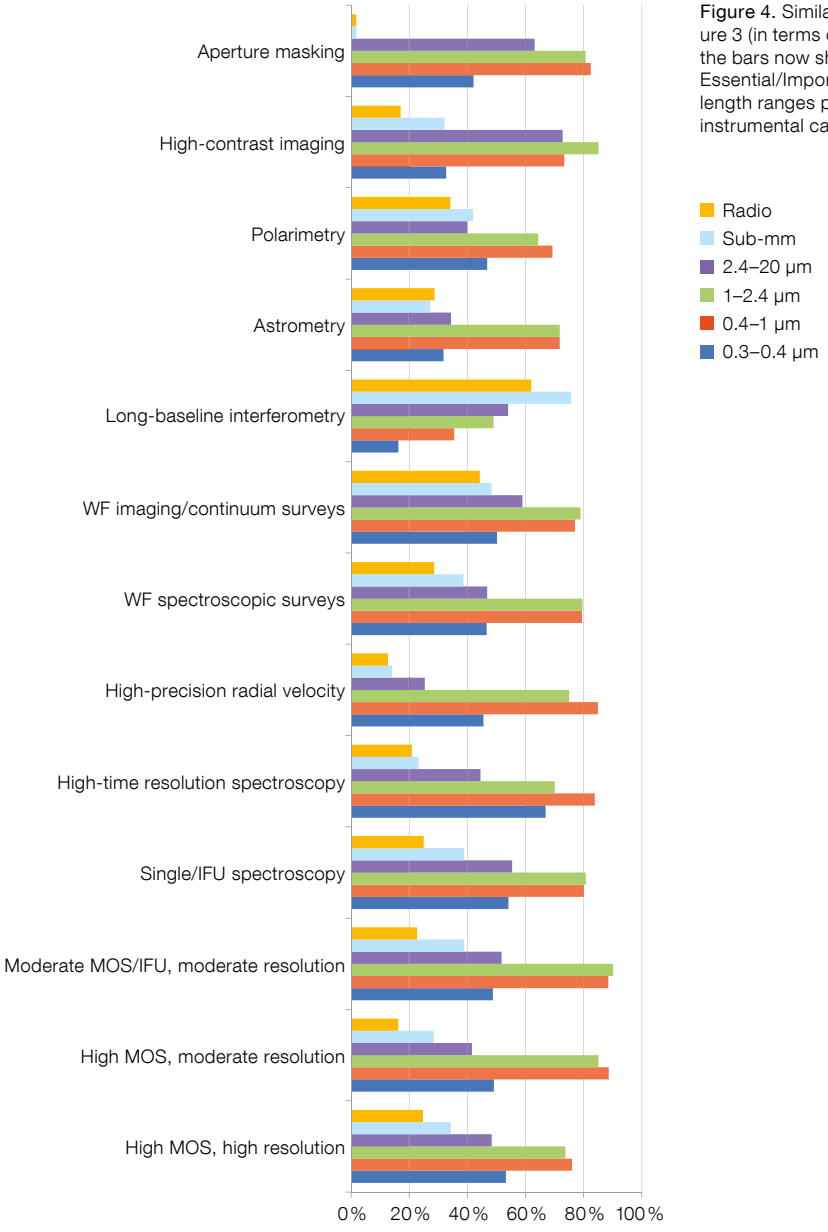


Figure 4. Similar to Figure 3 (in terms of y-axis), the bars now show the Essential/Important wavelength ranges per chosen instrumental capability.

objectives). The response to the question whether there were observing capabilities not available at ESO split almost equally (46 % Yes, 54 % No); those who answered "Yes" were asked to be more specific. There were nearly 800 individual comments spanning a wide range of options and mixing both capabilities (to the level of a specific instrument mode missing on an already operational VLT instrument) and facilities (e.g., X-ray and gamma ray).

Figure 6 displays which other facilities our pool of respondents deem to be essential for their future research objectives. A list of upcoming planned facilities was provided, but users were allowed to specify more and they are shown by the word cloud.

Section III — Time scheduling and observing modes

Sections III and IV covered ESO science policies and their implementation in terms of observing (this section) and data processing/archive capabilities (next section).

Almost twenty years ago, while preparing for the VLT, ESO captured its main policies and procedures on how to allocate telescope time at the VLT/VLTI in what then became the official ESO Science Policy document[2]. The arrival of VLT/I clearly marked a significant change for ESO and its community, moving from a classical type of observatory (how La Silla was run, back then) to a more challenging model that makes the best out of classical and queue observing (Visitor and Service Modes, VM and SM, respectively). Today, ESO's facility landscape has been further enriched and now includes Visible and Infrared Survey Telescope for Astronomy (VISTA) and the VLT Survey Telescope (VST) on Paranal, APEX and ALMA on Chajnantor. In the 2020+ timeframe, it will also include the E-ELT.

Despite several commonalities among its observatories, ESO operates its facilities in slightly different ways: only Visitor Mode observing on La Silla; only Service Mode observing on the two survey telescopes (VISTA and the VST), APEX and ALMA; both Service and Visitor Modes at the VLT/I. Section III touched on these aspects and probed the community's needs and ideas about types of observing programmes and observing modes (one question each, see Table 3). Neither question was mandatory. For the first question of Section III (Table 3), each programme type listed among the possible options scored the same number of responses (1775). This is because each entry had "No Answer" ticketed as the default value. Figure 7 thus shows the percentage of responses for the five types of programme, each of which sum to 100 % of the responses.

The community expressed its strongest opinion about the necessity to have regular observing programmes, defined as an essential and/or very important channel to fulfil their research objectives, followed by Large Programmes and Public Surveys with a robust number of preferences (Essential, Very Important and Important). The overall opinion about Filler and Director's Discretionary Time Programmes is less clear: the responses are distributed more evenly among all priorities, though both have the largest percentage of "Not Important" responses (still relatively small,

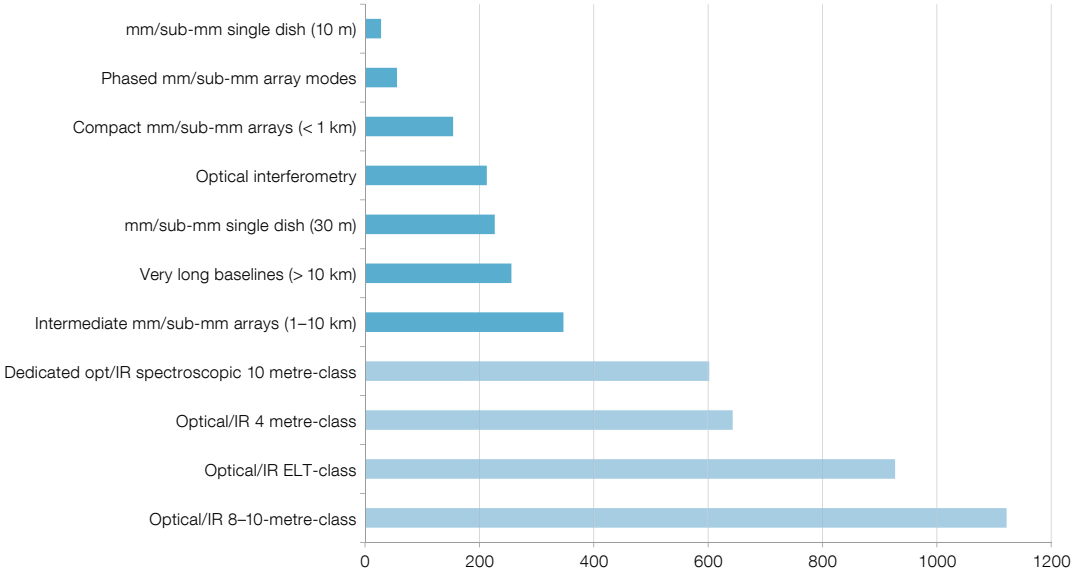


Figure 5. Users were asked to select which facilities will be required for their future research objectives. A total of 4575 responses were received. The bottom four bars (light blue) make up 72 % of all responses.

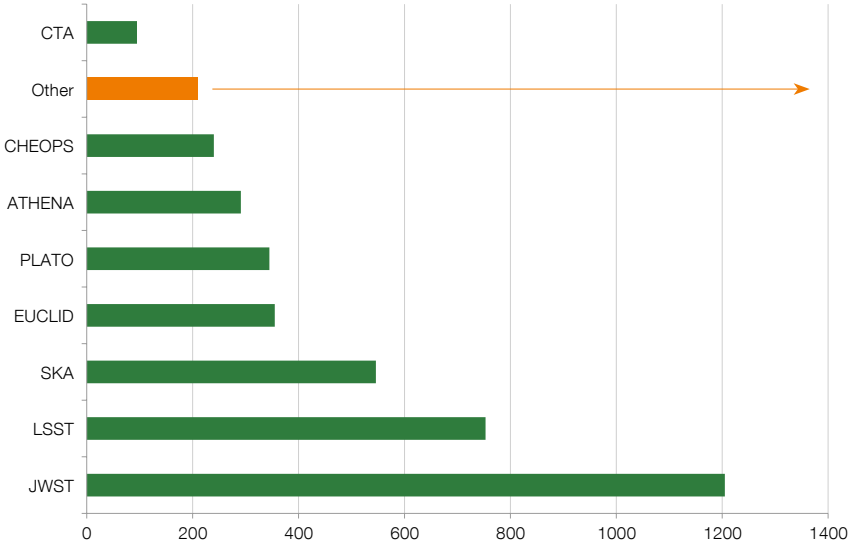


Figure 6. Bar chart and word cloud visualisation of the other facilities that users will likely use in the future. A total of 4039 responses were received.

Table 3. Questions from Section III of the ESO2020+ Users' Poll.

Section III – Time scheduling and observing modes		
3.1	How important do you consider the following types of programme for your research objectives?	See Figure 7
3.2	Which of the following observing and scheduling capabilities are important for your research objectives?	See Figure 8

8 % and 12 % respectively). The majority of the respondents seem to have no specific opinion about these programme categories, which could also imply that their science programmes cannot be carried out as Filler Programmes, for example. For Filler Programmes in particular, this result will need to be reconciled with the ~ 40 % preference scored for the use of filler queues to exploit poor weather at La Silla Paranal (see Figure 8).

Next the users were faced with the question on the importance of the most common observing and scheduling capabilities for their own research objectives. The question was not mandatory and asked the users to specify their priorities for each of the three major ESO facilities, La Silla Paranal Observatory, ALMA and the E-ELT. Figure 8 summarises the results in terms of percentages corresponding to the number of preferences received and normalised to the total number of respondents (1775). Each facility should be looked at as an independent entry, since users were allowed to select any given option for all three facilities. In other words, if we take the Visitor Mode option at the bottom of the plot,

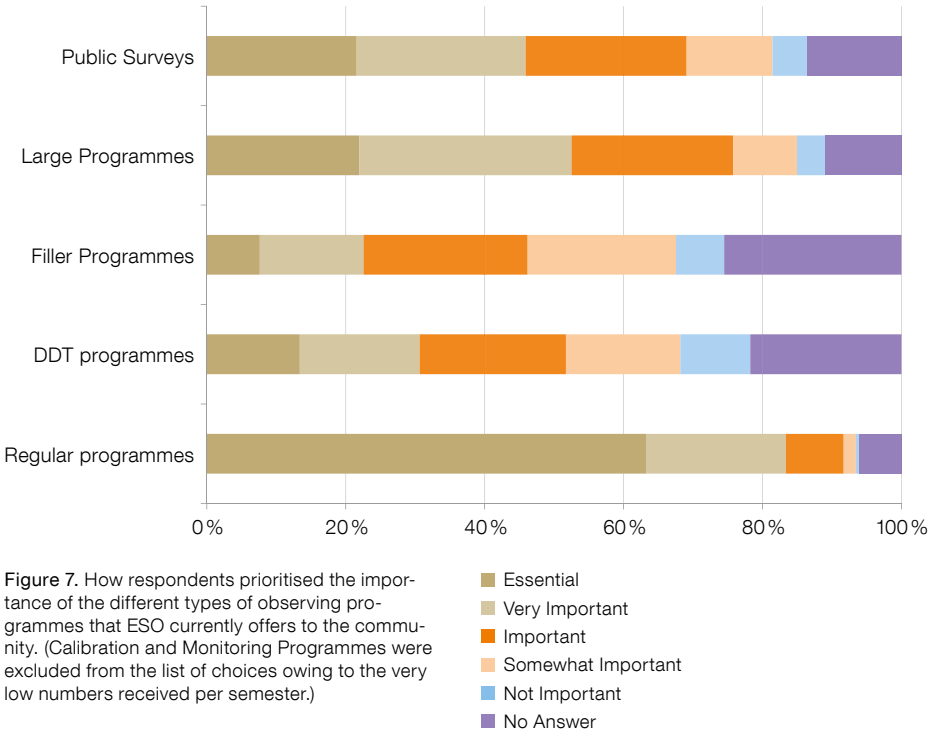


Figure 7. How respondents prioritised the importance of the different types of observing programmes that ESO currently offers to the community. (Calibration and Monitoring Programmes were excluded from the list of choices owing to the very low numbers received per semester.)

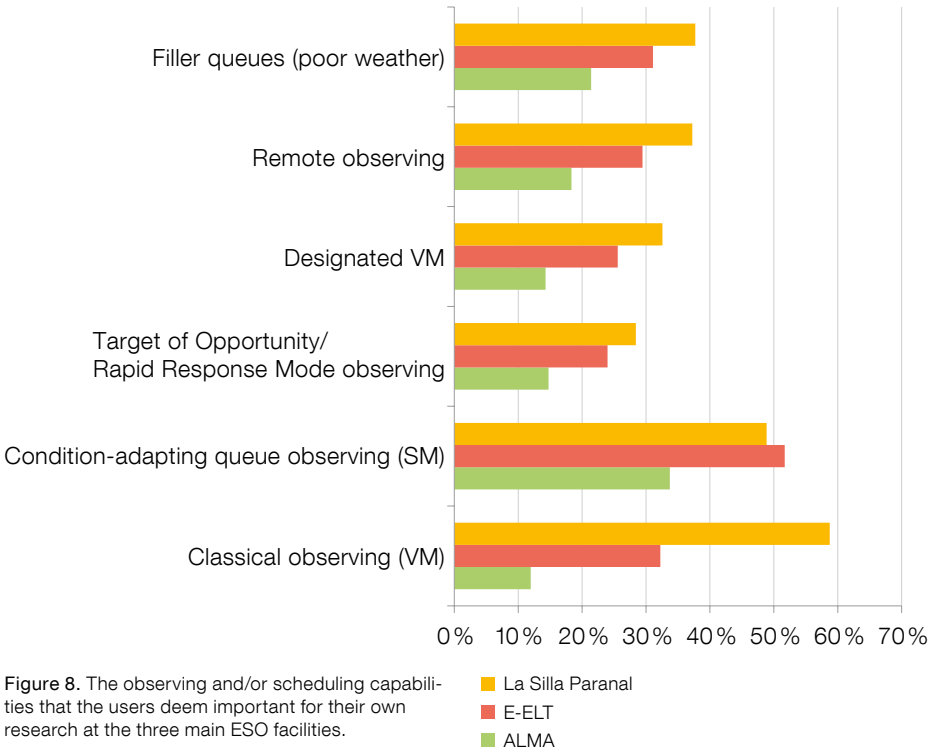


Figure 8. The observing and/or scheduling capabilities that the users deem important for their own research at the three main ESO facilities.

it means that 60% of respondents selected this option as important for their own research plans at La Silla Paranal. Nothing can be said about the remaining 40%: based on how the question was posed one could assume that 40% find Visitor Mode not important/relevant. However, we cannot exclude *a priori* that this 40% includes also those who would define themselves as "neutral", without a strong opinion about this specific mode.

A few remarks are in order. Condition-adapting queue observing is the mode that received the largest (absolute) number of preferences for both ALMA and the E-ELT and is one of the two preferred modes for La Silla Paranal. This is a clear recognition of the importance of what we call Service Mode for an optimised exploitation of ESO facilities. Noteworthy are the large number of preferences received by the option for classical observing (Visitor Mode) for La Silla Paranal, significantly larger than what could be considered alternative options, like Designated Visitor Mode or Remote Observing.

Section III offered users the opportunity to leave comments on missing capabilities and/or issues related to observing modes and scheduling. The variety of comments (approximately 150 in number) makes it impossible to render them in any graphical way. Among the responses were: Remote Observing as an important development for the future (independently of the facility); Service Mode observing on La Silla to better cope with monitoring programmes; more interactions with ALMA observing (also in terms of dedicated schools on ALMA hardware); more synergies with space missions (ESO involved as partner from the beginning, especially for those missions that will require ground-based support as part of their goals).

Section IV — Data management and services

Data management is part of both ESO's and ALMA's operational infrastructures: entailing the archiving of all raw science and calibration data; checking the performance of the instruments so that corrective measures can be applied in a timely manner; and making data available to the Principal Investigators (PIs) in real time and to the wider community later on.

Section IV aimed to collect feedback on aspects related to the exploitation of individuals' science data. This section comprised four main questions (see Table 4)

Table 4. Questions from Section IV of the ESO2020+ Users' Poll.

Section IV – Data management and services		
4.1	How important are the following data reduction software capabilities for your research objectives?	See Figure 9
4.2	How important is access to the following sorts of archived data products in order to maximise your scientific productivity?	See Figure 10
4.3	To maximise the scientific impact of data from ESO facilities, bearing in mind that ESO has finite resources, what level of support should be provided for ESO data? Currently all raw (science and calibration) data and data products are archived.	See Figure 12
4.4	For your research, how critical are the following functions/capabilities?	See Figure 11

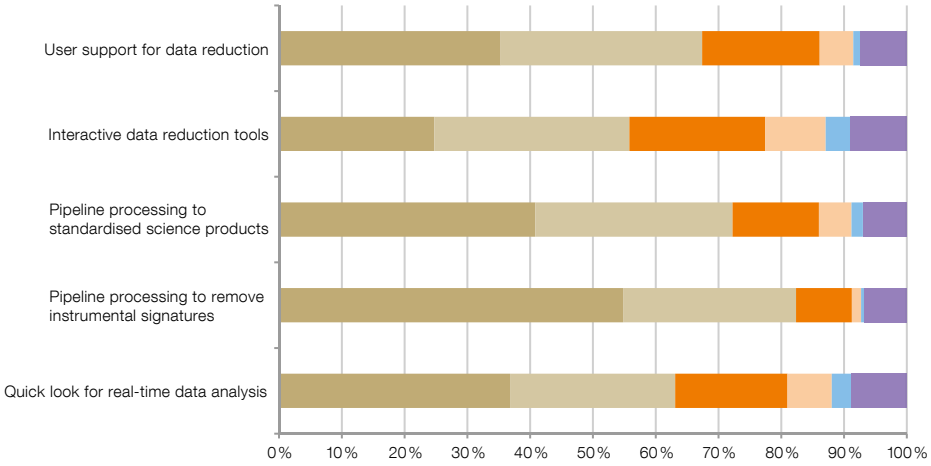
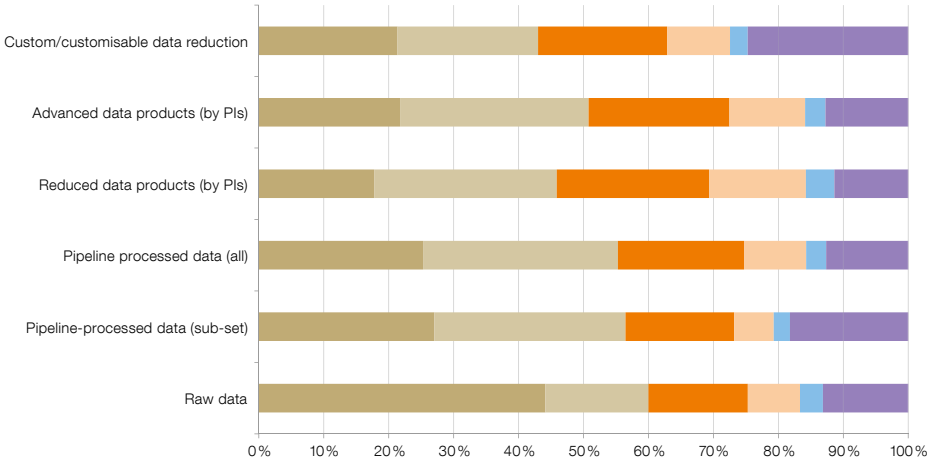


Figure 9 (above). Distribution of users' opinions and priorities on the availability of specific data reduction capabilities.

Figure 10 (below). Distribution of users' opinions and priorities on accessing specific data products (as listed on the y-axis).



and further opportunities to provide individual feedback. None of the questions required a mandatory answer, with a default No Answer option (to be interpreted as having no specific opinion).

Three out of the four questions were formulated in view of the respondents' research objectives and scientific productivity. The users were asked to express their opinion on the importance of: 1) different data reduction software capabilities for their research activities; 2) access to a variety of data products in order to maximise scientific productivity; 3) specific functions/capabilities. The fourth question was formulated in more general terms and required the respondents to express their views on which level of data support (both in terms of data processing and data archiving) would be needed to maximise the scientific impact of data collected at ESO facilities. Figures 9–12 summarise the distribution of responses in terms of criticality.

There is a lot of information embedded in these figures, which clearly calls for a more in-depth analysis. The most obvious take-away message is that users consider support for data products (via tools to properly treat the data and/or via types of products made available to them through the ESO Science Archive) extremely important for their own research activities. In fact, approximately half of the respondents consider it critical to have advanced data reduction tools and pipelines for their research projects (55 %, see Figure 11) and believe that ESO should routinely process and archive most or all science data in order to maximise the impact of ESO data (50 %, see Figure 12).

Most questions of this section (4.1, 4.2 and 4.4, see Table 4) were formulated in order to collect the broadest overview on the different levels of importance of several aspects related to data management. The respondents were not asked to prioritise their preferences, therefore we are unable to go deeper in the interpretation of the distribution of responses. For example, we note that for question 4.2, i.e., how essential/very important is the access to different types of archived data products for one's individual research, all options (raw data, pipeline processed data (subset), pipeline processed data [all]) scored around 55–60 %, despite the fact that the latter two options could have also been interpreted as mutually exclusive. Similarly, one may question how significant the differences are between the other options: advanced data products created by the PIs scored 51 %, followed by reduced data products created by PIs (46 %) and custom/customisable data reduction (43 %).

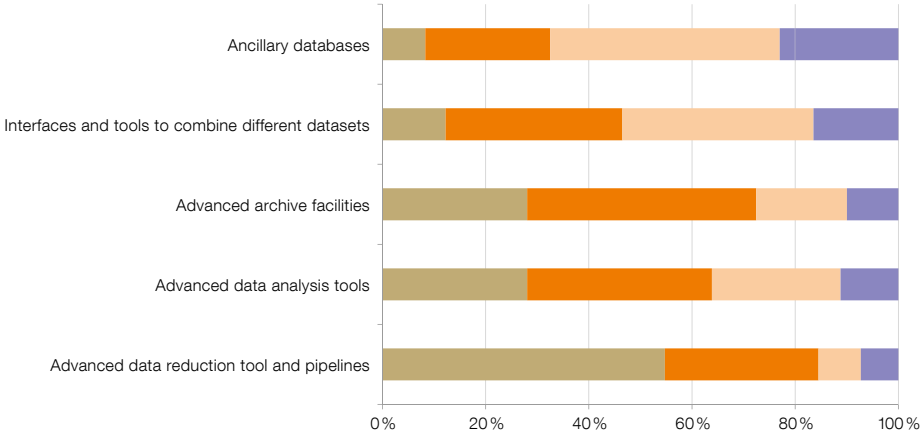


Figure 11 (above). Distribution of user answers on five different data-related functions/capabilities. The default choice was set to No Answer and users were warned that this would be interpreted as having no particular opinion on that specific item.

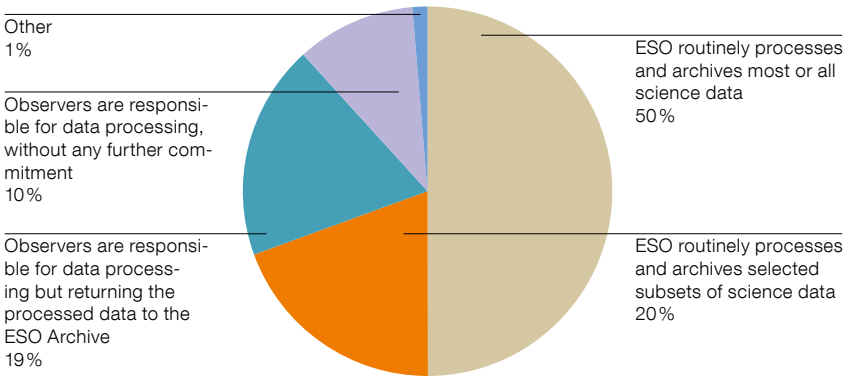


Figure 12 (below). Distribution of responses on the level of support that ESO should provide.

On the other hand, in question 4.4, about the criticality of different functions/capabilities for one's research, the differences among the proposed options are more significant (see Figure 11). Here, for instance, 55% of the respondents consider it critical to have advanced data reduction tools and pipelines available, but only 28% asked for advanced archive facilities.

With respect to the level of overall support that should be provided for ESO data, half of the community is of the opinion that most or all science data should be routinely processed and archived, whereas the other alternative options (selective processing of datasets by ESO and PI data processing with commitment to return the data products to ESO) scored only 20% each.

Concluding remarks

The poll was a successful exercise, both in terms of the number of responses and the quality and relevance of feedback received. As is always the case, our poll suffers from some intrinsic biases. The results are, however, sufficiently solid to guide and support future implementations. The community poll represents an important component of the ESO2020+ Science Prioritisation exercise and it was folded into the final recommendations prepared by the working group.

The ensemble of opinions represents the largest feedback ever collected by ESO from its users in a systematic manner. It provides important details about our astronomical community, in terms of its current scientific interests, future research goals and expectations.

We believe that this poll will serve ESO well in different respects: there is an enormous amount of information, not only for ESO2020+, but also for the more immediate future of ESO, on existing facilities and instrument capabilities already available to the community. Apart from the area of future facilities, for which many other considerations have to be considered, the areas pertinent to science policies and their implementation (operations) have provided a clear picture in terms of types of programmes, observing modes and data support. The poll has indicated how essential regular observing programmes are, on all facilities — the respondents acknowledge the importance of Large Programmes and the new trend of Public Surveys, but they have emphasised the need to keep regular observing programmes on all ESO facilities, i.e., there continues to be strong support for research projects led by individuals and small groups. Regarding data support, the poll results show that the community appreciates the end-to-end support provided by ESO (e.g., ESO should process and archive most of the science data).

We will continue to search for interesting correlations among the results. For instance, a test between the career stage of the respondent and the preferred level of support that ESO should provide, in terms of data processing and data archiving, showed that the younger generations may have different views from their senior colleagues. It is thus important to understand the invaluable feedback received from the ESO community via the poll in order to maintain ESO at the forefront of future astrophysical and technological developments.

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Links

[1] Science Priorities at ESO: http://www.eso.org/public/about-eso/committees/stc/stc-85th/public/STC-551_Science_Priorities_at_ESO_85th_STC_Mtg_Public.pdf
[2] ESO Science Policy document: http://www.eso.org/sci/observing/policies/cou996-rev.pdf